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The Generation of High Power Radio Frequency Pulses by Means of an Exploding Wire Technique

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Prepared for DEPUTY COMMANDER AEROSPACE SYSTEMS
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
Inglewood, California

PHYSICAL RESEARCH LABORATORY •

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THE GENERATION OF HIGH POWER RADIO FREQUENCY PULSES BY MEANS OF AN EXPLODING WIRE TECHNIQUE

by

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ABSTRACT

A method is described for generating high power radio frequency pulses lasting only a few microseconds, which involves discharging a capacitor through a triggered spark gap in series with an exploding wire and a radiofrequency tank circuit. To illustrate the method, a particular experiment is presented.

THE GENERATION OF HIGH POWER RADIO FREQUENCY PULSES
BY MEANS OF AN EXPLODING WIRE TECHNIQUE

Some plasma physics experiments require high power radio frequency pulses having a duration of only a few microseconds. One method of obtaining such pulses using a saturable core reactor has been described by Westendorp and Hurwitz.[1]

Another method of obtaining such pulses involves discharging a capacitor through a triggered spark gap in series with a fine copper wire and a radio frequency tank circuit The initial surge of current which passes through the copper wire before it explodes charges the tank circuit For some microseconds after the wire has exploded, the tank circuit is effectively isolated from the low frequency charging circuit. (This period is referred to as the "current dwell" in exploding wire literature [2]) During this dwell time, the tank circuit oscillates with a decay time determined only by the losses in the inductive and capacitative sections of the tank circuit This method of charging the tank circuit removes the necessity for a conventional switch in that circuit and thus eliminates a reduction in the Q of the circuit due to ohmic losses in such a switch.

The circuit diagram is shown in Fig 1 The component values listed are for a particular experimental test The low frequency charging circuit consists of a 0.25 microfarad capacitor charged to 30 kilovolts connected in series with an exploding wire gap and a 0 155 microhenry inductor which constitutes the inductive section of the tank circuit The exploding wire gap in this particular instance was three inches wide and included a two-inch-high barrier of quarter-inch-thick Micarta sheet The radio frequency tank circuit consists of the 0 155 microhenry inductor and a 0.029 microfarad capacitor; the resonant frequency of this circuit is 2 74 megacycles per second.

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1 W F Westendorp and H. Hurwitz, Jr , <u>Rev. Sci. Instr</u>. <u>31</u>, 662 (1960).

2. W G Chace and H. K Moore eds , <u>Exploding Wires</u> (Plenum Consultant s Bureau Enterprises, Inc , New York 1959).

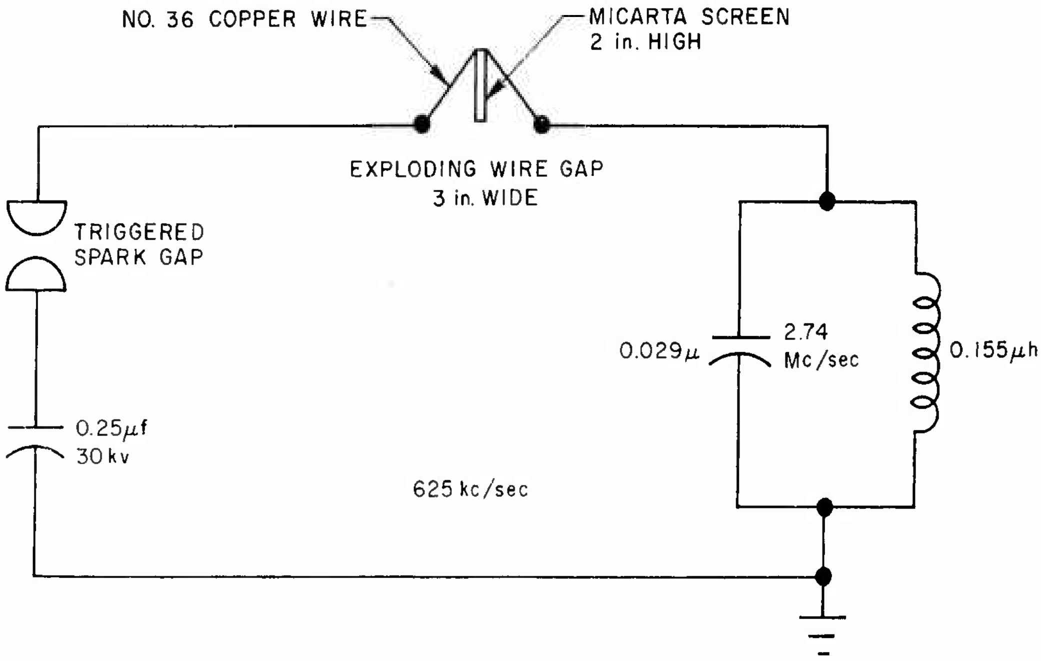

Fig. 1. Circuit diagram.

When the exploding wire gap is shorted out with a heavy copper strap and the 0.029 microfarad capacitor is disconnected, the current through the 0.155 microhenry inductor due to the discharge of the 0.25 microfarad capacitor has the waveform shown in Fig. 2a. When No. 36 copper wire is placed in the gap and the 0.029 microfarad capacitor is reconnected across the inductor, the current through the inductor has the waveform shown in Fig. 2b. It is seen that for six microseconds following the explosion of the wire, the tank circuit oscillates with a Q, determined from the decay of the wave train, of 88. This value of Q agrees with that measured independently with a signal generator and detector. The peak current attained in the radio frequency pulse is 7.2 kiloamperes. This represents 52 megavolt amperes of circulating apparent power in the tank circuit.

In this particular instance, there was a 2.5 percent transfer of energy from the low frequency charging circuit to the tank circuit. The energy transfer is strongly dependent on the ratio of the "switch-off time" to the period of the radio frequency oscillation, the switch-off time being the time taken for the current flowing through the copper wire to decrease to a very low value after the explosion of the wire. The smaller this ratio, the better the energy transfer. It has been found that, in general, for a given wire diameter and a given charging capacitor, the switch-off time decreases with both a decrease in the total length of the wire and an increase in the charging capacitor voltage. Both of these latter procedures, however, have an effect of decreasing the current dwell time.

Fig. 2a.

Fig. 2b.

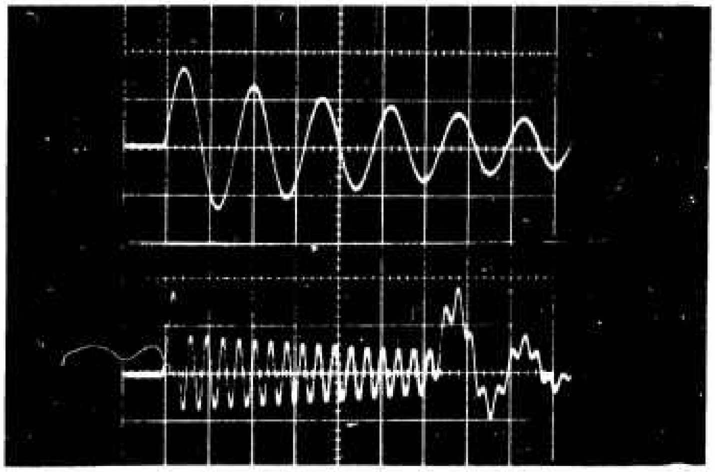

Fig. 2. Waveform of current in 0.155 μh inductor. The sweep rate for both traces is 1 μsec/cm.

a. Trace at 18.4 k-amp/cm, with copper strap in exploding wire gap.

b. Trace at 9.2 k-amp/cm, with No. 36 copper wire in gap.

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